

nanotubes either side-to-side or end-to-end.

#### SUMMARY OF THE INVENTION

The inventors have now developed a process capable of linking nanotubes. Importantly, the inventors have developed a process, which allows linkage of nanotubes either side-to-side or end-to-end, thereby dramatically increasing their usefulness. The inventors have also developed a process of physically modifying the walls of nanotubes, while preserving the  $sp^2$  structure of the nanotubes and thus their electronic characteristics. The inventors have also developed a method for locating nanotubes to specific targets. The inventors have also developed techniques which allow DNA patterning on nanotubes as well as the creation of multiple layers of nanoparticles on the surface of nanotubes.

In its broadest aspect, the invention provides a method of chemically attaching nucleic acid molecules to one or more nanotubes. The invention also provides a method of physically attaching nucleic acid molecules to one or more nanotubes. The invention also provides a method of linking these nanotubes. Further, the invention provides a process whereby nanotubes may be directed to specific locations.

Accordingly, in a first aspect, the present invention provides a nanotube with one or more nucleic acid molecule(s) attached thereto.

In a second aspect, the invention provides a method of chemically modifying a nanotube comprising either:

- (i) a) chemically attaching at least one linker attached to one or more nucleic acid molecules to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group with the proviso that when the nanotube is functionalised with  $CO_2H$ , then the linker is not a primary aliphatic alkyl amine; and

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b) synthesising at least two nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said one or more nucleic acid molecules; or

(ii) a) chemically attaching at least one linker attached to one or more nucleic acid molecule to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and

b) synthesising at least two nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said one or more nucleic acid molecules; or

(iii) a) chemically attaching at least one linker to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and

b) attaching one or more nucleic acid molecules to said optionally functionalised nanotube via said functional group on said linker; or

(iv) (a) chemically attaching at least one linker to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and

b) synthesising one or more nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said functional group on said linker.

In a third aspect, the invention provides a method of chemically modifying a nanotube comprising either:

(i) a) photochemically attaching at least one linker attached to one or more nucleic acid molecules to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and

b) synthesising at least two nucleic acid molecules by sequential addition of nucleotides *in situ*, starting from said one or more nucleic acid molecules; or

(ii) a) photochemically attaching at least one linker to an optionally functionalised nanotube, wherein the linker consists wholly or partly of a functional group; and

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b) attaching one or more nucleic acid molecules to said optionally functionalised nanotube via said functional group on said linker; or

(iii) a) photochemically attaching at least one linker to an optionally functionalised nanotube, wherein the linker consists wholly or partly of a functional group; and

b) synthesising one or more nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said functional group on said linker.

In a fourth aspect, the invention provides a method of physically modifying a nanotube comprising either:

(i) a) physically adsorbing at least one anchor attached to one or more nucleic acid molecules to the surface of an optionally functionalised nanotube, wherein said anchor consists wholly or partly of a functional group;

b) synthesising at least two nucleic acid molecules by sequential addition of nucleotides *in situ*, starting from said functional group on said anchor; or

(ii) a) physically adsorbing at least one anchor to the surface of an optionally functionalised nanotube, wherein said anchor consists wholly or partly of a functional group; and

b) chemically attaching one or more nucleic acid molecules to said functional group on said anchor adsorbed on the optionally functionalised nanotube; or

(iii) a) physically adsorbing at least one anchor attached to one or more nucleic acid molecules to the surface of an optionally functionalised nanotube, wherein said anchor consists wholly or partly of a functional group;

b) synthesising one or more nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said functional group on said anchor.

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In a fifth aspect, the invention provides a plurality of linked nanotubes.

5 In a sixth aspect, the present invention provides a method of linking nanotubes comprising the steps of:

- a) attaching a first nucleic acid molecule of a first base sequence to a first optionally functionalised nanotube; and
- 10 b) hybridizing the first nucleic acid molecule with

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A nanotube with one or more nucleic acid molecule(s) attached thereto.
2. A method of chemically modifying a nanotube comprising either:
- (i) a) chemically attaching at least one linker attached to one or more nucleic acid molecules to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group with the proviso that when the nanotube is functionalised with  $\text{CO}_2\text{H}$ , then the linker is not a primary aliphatic alkyl amine; and
- b) synthesising at least two nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said one or more nucleic acid molecules; or
- (ii) a) chemically attaching at least one linker attached to one or more nucleic acid molecule to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and
- b) synthesising at least two nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said one or more nucleic acid molecules; or
- (iii) a) chemically attaching at least one linker to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and
- b) attaching one or more nucleic acid molecules to said optionally functionalised nanotube via said functional group on said linker; or
- (iv) a) chemically attaching at least one linker to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and
- b) synthesising one or more nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said functional group on said linker.

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3. A method of chemically modifying a nanotube comprising either:

5 (1) a) photochemically attaching at least one linker attached to one or more nucleic acid molecules to an optionally functionalised nanotube, wherein said linker consists wholly or partly of a functional group; and

(b) synthesising at least two nucleic acid molecules by sequential addition of nucleotides *in situ*, starting from said one or more nucleic acid molecules; or

10 (ii) a) photochemically attaching at least one linker to an optionally functionalised nanotube, wherein the linker consists wholly or partly of a functional group; and

b) attaching one or more nucleic acid molecules to said optionally functionalised nanotube via said functional group on said linker; or

15 (iii) a) photochemically attaching at least one linker to an optionally functionalised nanotube, wherein the linker consists wholly or partly of a functional group; and

20 b) synthesising one or more nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said functional group on said linker.

25 4. A method of physically modifying a nanptube comprising either:

30 (i) (a) physically adsorbing at least one anchor attached to one or more nucleic acid molecules to the surface of an optionally functionalised nanotube, wherein said anchor consists wholly or partly of a functional group;

b) synthesising at least two nucleic acid molecules by sequential addition of nucleotides *in situ*, starting from said functional group on said anchor; or

35 (ii) a) physically adsorbing at least one anchor to the surface of an optionally functionalised nanotube, wherein said anchor consists wholly or partly of a

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functional group; and

b) chemically attaching one or more nucleic acid molecules to said functional group on said anchor adsorbed on the optionally functionalised nanotube; or

5 (iii)a) physically adsorbing at least one anchor attached to one or more nucleic acid molecules to the surface of an optionally functionalised nanotube, wherein said anchor consists wholly or partly of a functional group;

10 b) synthesising one or more nucleic acid molecules, by sequential addition of nucleotides *in situ*, starting from said functional group on said anchor.

15 5. A method of linking nanotubes comprising the steps of:

a) attaching a first nucleic acid molecule of a first base sequence to a first optionally functionalised nanotube; and

20 b) hybridising the first nucleic acid molecule with a second nucleic acid molecule of a second base sequence attached on a second optionally functionalised nanotube, wherein the base sequence of the second nucleic acid molecule is substantially complementary to the base sequence of the first nucleic acid molecule.

25 6. A method of linking nanotubes comprising the steps of:

30 a) attaching a first nucleic acid molecule of a first base sequence to optionally functionalised nanotubes; and

b) hybridising the first nucleic acid molecule with a second nucleic acid molecule which comprises a base sequence substantially complementary to the first base sequence and further comprises a second or a third base sequence which is/are not complementary to the first base sequence, but is/are complementary to each